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Effects of Regulated Lake Levels on Northern Pike Spawning Habitat and Reproductive Success in Namakan Reservoir, Voyageurs National Park

United States Department of the Interior

National Park Service - Midwest Region

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EFFECTS OF REGULATED LAKE LEVELS ON NORTHERN PIKE SPAWNING HABITAT AND REPRODUCTIVE SUCCESS IN NAMAKAN RESERVOIR, VOYAGEURS NATIONAL PARK

by Larry W. Kallemeyn

NATIONAL PARK SERVICE - Midwest Region

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Dewatered area along Daley Brook, Voyageurs National Park. (From the park's general collection)

ABSTRACT

The effects of regulated lake levels on northern pike spawning habitat availability and reproductive success were evaluated in Namakan Reservoir, Voyageurs National Park. Topographic maps of two tributary deltas and the results of vegetative cover type surveys were combined to quantify the amount of northern pike spawning habitat between 1112 and 1117 ft above mean sea level (msl). Total areas of the two deltas at the upper elevation were 148 and 203 acres, of which 19% and 29%, respectively, consisted of emergent vegetation or potential northern pike spawning habitat. Since over 90% of the emergent vegetation occurs above 1115 ft msl, a 5- to 6-foot rise in the lake level must occur to flood and provide access to the preferred substrate for egg deposition. Northern pike reproductive success was higher when this occurred. With the present water management program this would not occur during the spawning season in most years. The frequency with which lake levels reach the spawning grounds during the spawning season can be increased by providing higher water levels earlier in the spring and by having a summer drawdown of two to three feet that promotes the establishment of emergent vegetation at lower elevations.

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INTRODUCTION

Regulated lake levels in Voyageurs National Park are believed to limit spawning habitat availability and reproductive success of spring spawners such as northern pike (*Esox lucius*). Under the present water management program, all wetland or apparent northern pike spawning areas in Namakan Reservoir are routinely de-watered by late March or early April. This may be limiting the recruitment of northern pike in park waters since this species is a spring spawner that prefers to spawn on a mat of short vegetation comprised of grasses and sedges (Fabricius and Gustafson 1958; Franklin and Smith 1963; McCarraher and Thomas 1972). A weak or poor year class is usually produced when the availability of flooded vegetation is limited by low spring water levels (Johnson 1957; Franklin and Smith 1963; Hassler 1970).

In 1981, the National Park Service initiated an investigation to obtain more detailed knowledge of the relationship between the present water management program on Namakan Reservoir and northern pike reproduction and survival. This paper presents results from that portion of the study dealing with northern pike spawning habitat availability at various lake levels, the frequency with which it is flooded under the present water management program, and the effect on reproductive success.

STUDY AREA

Namakan Reservoir encompasses Crane, Sand Point, Namakan, and Kabetogama Lakes (Fig. 1). These four lakes, which have a combined acreage of approximately 63,000 acres, are natural lakes whose water levels were originally controlled by natural rock sills at the outlet of Namakan Lake. Two dams constructed at

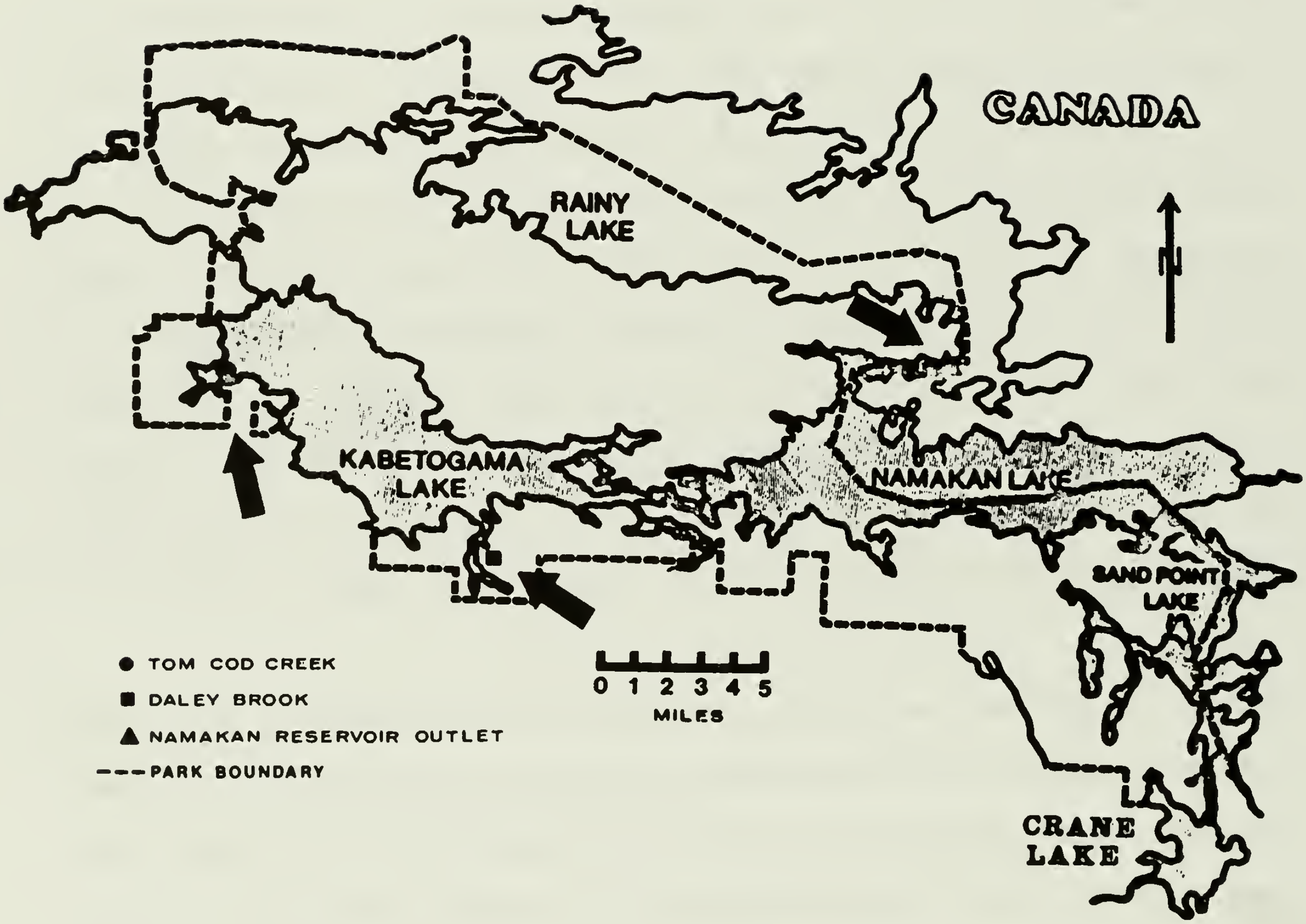

Figure 1. Map of Voyageurs National Park (---) and Namakan Reservoir (shaded area).

this outlet in 1914 are now used to regulate the water levels of the four lakes for the authorized purposes of navigation, flood control, pollution abatement, power generation, and fish propagation. Since portions of two of these lakes lie in Canada, the dams and lake levels are regulated by the International Joint Commission. The present water management program or "rule curve" requires that water levels be within a defined band of lake elevations at any particular time of the year (Fig. 2). The water level pattern consists of a gradual fall and winter drawdown followed by a spring and early summer buildup to peak levels which are maintained throughout the summer and early fall. The present average annual lake level fluctuation of nine feet is approximately three feet greater than the estimated "natural" or pre-dam fluctuation (Flug 1986).

The Kabetogama Lake portion of Namakan Reservoir was selected as the study area because it appeared to have the greatest potential for northern pike production and it was the most accessible of the four lakes. At its normal summer elevation of 1118.6 ft above mean sea level (msl), Kabetogama Lake has the following characteristics: surface area, 25,750 acres; maximum length, 15.6 miles; maximum width, 4.4 miles; maximum depth, 50 feet; shoreline length, about 131 miles; and a littoral zone (depth less than 15 feet) that encompasses approximately 30 percent of the lake area. Northern pike spawning habitat was evaluated in the deltas of Tom Cod Creek and Daley Brook, two tributaries of Kabetogama Lake. The two deltas are approximately 8.5 miles apart, with Tom Cod Creek entering the lake at its west end and Daley Brook entering near the midpoint of the south shore.

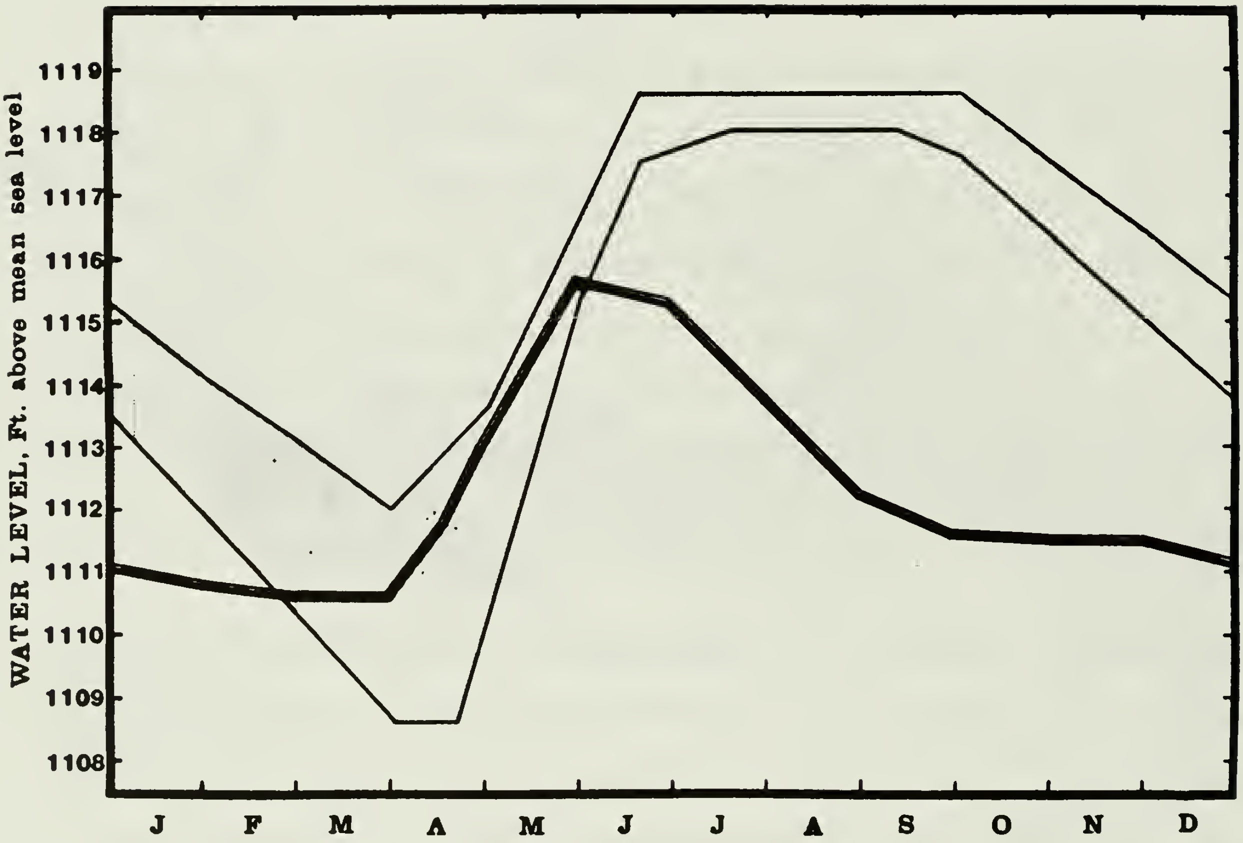

Figure 2. Namakan Reservoir operating rule curve (shaded area) and computed natural lake levels (═). Adapted from Flug 1986.

METHODS

Prior to spring flooding in 1983, the Tom Cod Creek and Daley Brook deltas were surveyed using a profile leveling technique (Schwab et al. 1963). At the same time, a vegetative cover type survey was conducted along the survey transects. Ocular estimates were made of the percent cover of three cover types within a .001-acre circle. Estimates were made at the midpoint when the horizontal distance between the adjacent contours was less than 15 feet, near both ends when the distance was from 15 to 22 feet, and at three evenly spaced points when it was greater than 22 feet. The three cover types were (1) mud which consisted primarily of silt and clay but that also contained small patches of peat-like material, (2) vegetative litter comprised of the remains of floating-leaved and submersed macrophytes, and (3) emergent vegetation which consisted primarily of common cattail (*Typha latifolia*) and bulrush (*Scirpus* sp.).

Survey results were used to prepare topographic maps with one foot contours. Total areas and areas within each contour were determined with a planimeter. Areas covered by each cover type within a contour were calculated by multiplying the total area of the contour by the mean percent occupied by each cover type within that contour. All water level data used in calculating stage-area relationships were taken from the Water Survey of Canada's station at Namakan Lake above Kettle Falls Dam. Ice-out dates were taken from a local newspaper, the *International Falls Daily Journal*.

Annual success of northern pike reproduction in Kabetogama Lake from 1983 to 1985 was estimated from catches of young-of-the-year from a sampling program using a seine and trap nets. Seine sampling with a 100 ft by 8 ft bag seine with 0.25-inch bar mesh was conducted bi-weekly from June through August at 16 stations. Trap nets with 0.5-inch bar mesh that had 4 ft by 4 ft frames and a 50 ft by 4 ft lead were set in July and August at thirty-two stations that were distributed throughout the lake. Trap nets with 0.25-inch bar mesh that had 6 ft by 3 ft frames and a 50 ft by 3 ft lead were set in September at 32 stations that were concentrated in tributary embayments, including those of Daley Brook and Tom Cod Creek. The mean catch per haul or set was considered to be the basic measure of abundance.

FINDINGS

Cover Type/Elevation Relationship

Total areas of Daley Brook and Tom Cod Creek deltas were 148.2 and 203.3 acres, respectively. In Daley Brook, the uppermost and lowermost of the six measured contour intervals comprised the largest portions of the total area, whereas in Tom Cod Creek the three upper intervals combined comprised approximately 70 percent of the total area (Table 1). The relatively large area below 1112 ft msl in Daley Brook was due to the stream channel itself comprising a relatively large portion of the total area. On Tom Cod Creek, however, the stream channel occupied a relatively small area and there were more extensive flat areas at higher elevations.

Mud was the dominant cover type in both deltas, covering 60.4 percent of the area in Daley Brook and 48.9 percent in Tom Cod Creek (Table 1). Although mud gradually decreased as the elevation increased, it still comprised over 50 percent of the cover in all except the upper two contours. Vegetative litter, which comprised similar portions of the total area in the two deltas, was most abundant in the intermediate contours, although it extended down to the 1112 to 1113 ft contour. Emergent vegetation, which was restricted primarily to the upper two contour levels, covered approximately 29 and 19 percent of the total area in Tom Cod Creek and Daley Brook, respectively.

Table 1. Cover type distribution in relation to lake-bed elevation in the deltas of Daley Brook and Tom Cod Creek, Kabetogama Lake. Percent (%) of total cover within a contour interval.

	Cover Type							
Elevation, ft above mean sea level	Mud		Vegetative Litter		Emergent Vegetation		Total Area acres	% of Total Area
	acres	(%)	acres	(%)	acres	(%)		
DALEY BROOK								
<1112	33.3	100.0	--	--	--	--	33.3	22.4
1112-1113	19.9	81.6	4.0	16.2	0.5	2.2	24.4	16.4
1113-1114	10.5	68.2	4.7	30.5	0.2	1.3	15.4	10.4
1114-1115	13.0	59.4	8.1	37.0	0.8	3.7	21.9	14.8
1115-1116	9.0	39.5	7.8	34.2	6.0	26.3	22.8	15.4
1116-1117	3.9	12.8	6.1	20.1	20.4	67.1	30.4	20.5
Total	89.6		30.7		27.9		148.2	
% of Total Area	60.5		20.7		18.8			
TOM COD CREEK								
<1112	12.8	100.0	--	--	--	--	12.8	6.3
1112-1113	22.8	93.4	1.2	4.9	0.4	1.6	24.4	12.0
1113-1114	17.7	78.7	4.4	19.6	0.4	1.8	22.5	11.1
1114-1115	23.6	53.2	15.7	35.4	5.1	11.5	44.4	21.8
1115-1116	13.8	33.0	14.3	34.2	13.7	32.8	41.8	20.6
1116-1117	8.7	15.2	8.6	15.0	40.1	69.8	57.4	28.2
Total	99.4		44.2		59.7		203.3	
% of Total Area	48.9		21.7		29.4			

With the observed cover type distribution, lake levels must exceed 1116 ft msl before the majority of the emergent vegetation becomes available for northern pike spawning. Flooding up to 1116 ft msl inundates approximately 7.5 acres of emergent vegetation in Daley Brook and 19.7 acres in Tom Cod Creek. Raising the lake level another foot to 1117 ft msl, however, would flood an additional

20 acres of emergent vegetation in Daley Brook and an additional 40 acres in Tom Cod Creek. While significant quantities of emergent vegetation also occur in the area that lies between the 1117 ft level and the normal summer lake level of 1118.6 ft msl, it is usually not flooded during the northern pike spawning season.

Ice-out/Spawning Habitat Availability Relationship

Ice-out on Kabetogama Lake, which is defined as the day the main lake becomes ice-free, has occurred as early as April 17 and as late as May 14 during the period 1952-1985 (Fig. 3). The median ice-out date for this period was May 1. Ice-out in tributaries such as Tom Cod Creek and Daley Brook usually occurs several days earlier than in the main lake. Although many pike enter these areas as soon as they become ice-free, spawning does not usually start immediately. Evaluation of the northern pike spawning runs in Tom Cod Creek and Daley Brook from 1981 through 1985 showed that spawning occurred primarily within the two- to three-week period following lake ice-out.

With the present water management program or "rule curve," most of the emergent vegetation suitable for northern pike spawning would not be flooded within three weeks of ice-out in most years. Assuming the lake is at the "rule curve's" maximum allowable level and based on the past timing of ice-out, water would reach the 1116 ft elevation within three weeks of ice-out approximately 41 percent of the time while it would not reach the 1117 ft level at all within that time span (Table 2). If the lake is at the "rule curve's" minimum allowable level, neither elevation would be reached within three weeks of ice-out. Since this rule curve went into effect in 1971, the water level has exceeded 1116 ft msl within three weeks of ice-out eight out

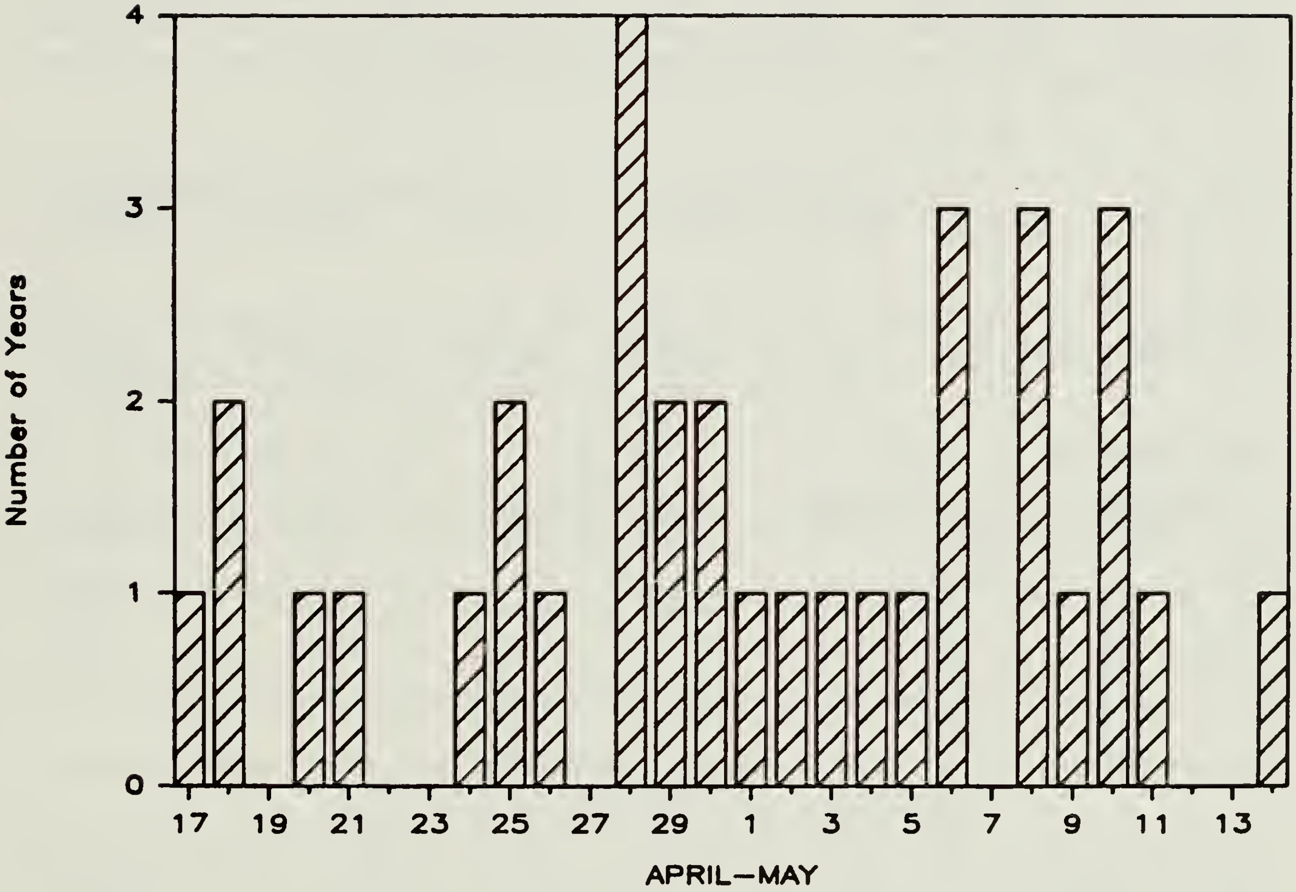

Figure 3. Distribution of ice-out dates from Kabetogama Lake, 1952-1985.

of fifteen years. In all instances where this occurred, lake levels were above the upper level of the rule curve.

Table 2. Frequency (%) of lake levels reaching 1116 and 1117 ft above mean sea level (msl) within two or three weeks of ice-out, based on the timing of ice-out on Kabetogama Lake, 1952-1985. Dates are targets for when the lake level should reach 1117 ft msl with those under the present "rule curve" being set at the maximum, mid-point, and minimum levels of the curve.

Weeks after ice-out	Present Rule Curve			Alternative Rule Curves		
	June 5	June 11	June 16	May 20	May 15	May 10
1116 ft msl						
Two	5.8	0.0	0.0	76.6	88.3	100.0
Three	41.1	5.8	0.0	91.2	100.0	100.0
1117 ft msl						
Two	0.0	0.0	0.0	26.4	50.0	76.6
Three	0.0	0.0	0.0	61.4	85.4	91.2

The frequency of flooding of the preferred spawning habitat within the three-week period following ice-out can be increased by assigning an earlier date for the water to reach the 1117 target elevation. Changing the target date from the present June 5 date to May 20 increases the chances of water reaching 1117 ft within three weeks of ice-out from zero to approximately 61 percent (Table 2). Moving the target date to earlier dates in May continues to increase the frequency of reaching 1117 ft within three weeks of ice-out. A target date of May 8 would be required to insure that 1117 ft is reached 100 percent of the time. Thus, the earlier the target date the greater the chance the northern pike spawning habitat will be flooded in any particular year, assuming the timing of ice-out remains the same.

Reproductive Success/Water Level Relationship

Fluctuations in water levels and reproductive success were similar with both the highest water levels and catches of young-of-the-year occurring in 1985 and the lowest in 1983 (Table 3). The numerically dominant 1985 year class was associated with a spring water level that exceeded 1116 ft. msl within three weeks of ice-out. The comparatively small catches in 1983 and 1984 were associated with water levels that only reached 1114 and 1115 ft. msl, respectively.

Table 3. Comparison of catch per seine haul and trap net set (catch/unit effort-c/f) of young-of-the-year northern pike with the water level three weeks after ice-out, Kabetogama Lake, 1983-1985.

Year	Water Level Ft. above msl	Seine		0.5 inch Trap net		0.25 inch Trap net	
		Hauls	c/f	Sets	c/f	Sets	c/f
1983	1114.0	95	0.01	64	0.06	32	0.16
1984	1114.9	95	0.02	64	0.08	32	0.22
1985	1116.7	95	0.04	63	0.35	32	0.75

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Flooded emergent vegetation plays an important role in the spawning and early life history of northern pike (Franklin and Smith 1963; Hassler 1970; Holland and Huston 1984). Presently, availability of flooded emergent vegetation during the spawning season in Namakan Reservoir is contingent upon lake levels actually exceeding the maximum levels allowed under the current water management program. When this occurs, such as in 1985, northern pike reproductive success is higher. Although this has occurred periodically, this "management by default" strategy does not appear to be the most reliable means of providing the necessary spawning habitat for northern pike on a long-term basis.

The frequency of flooding of the existing emergent vegetation in Namakan Reservoir can be increased by modifying the existing water management program so that it provides for higher lake levels earlier in the spring. Assuming the timing of ice-out remains the same, it appears the target date for the lake level to reach 1117 ft msl should be no later than May 15. This would provide for flooding of the northern pike spawning grounds within three weeks of ice-out approximately 85 percent of the time.

Another management strategy that could be combined with earlier, higher water levels would be to provide conditions that would allow emergent vegetation to grow at lower elevations, thereby making the emergent vegetation easier to flood in the spring and more readily available for spawning. Emergent vegetation in freshwater marshes has been found to be limited by high, stable water levels such as those now maintained on Namakan Reservoir throughout the growing season (Kadlec 1962; Harris and Marshall 1963). Drawdowns are commonly used by wetland and fisheries managers to overcome this limiting effect and to increase the distribution and diversity of emergent plant species (Kadlec 1962; Groen and Schroeder 1978; Keddy and Reznicek 1985). A model is available for predicting and evaluating the response of various emergent species to drawdowns and other changes in water levels (van der Valk 1981). Application of the model will require information on the life span, propagule longevity, and establishment requirements of the plants and seeds of plants that currently occur in Namakan's wetlands.

Drawing down the water level of Namakan Reservoir two to three feet between June 1 and September 1 could significantly expand the area covered by emergent vegetation at lower elevations. This change would be particularly beneficial in those years when runoff is limited since it would reduce the amount of spring rise in water level required to flood northern pike spawning habitat. The effectiveness of such a summer drawdown in increasing the distribution of Namakan's aquatic vegetation could be evaluated using van der Valk's (1981) model.

Implementation of these alternative water management strategies would restore conditions on Namakan Reservoir that more closely approximate the magnitude and timing of natural fluctuations in lake levels. The average summer water level fluctuation under pre-dam conditions is calculated to have been approximately three feet, with the maximum lake level occurring in early June (Flug 1986). Restoration of more natural lake level fluctuations in Namakan Reservoir would be in keeping with the National Park Service's mandate to protect, perpetuate, and restore natural aquatic environments and native species in national parks, such as Voyageurs (Hayden 1976).

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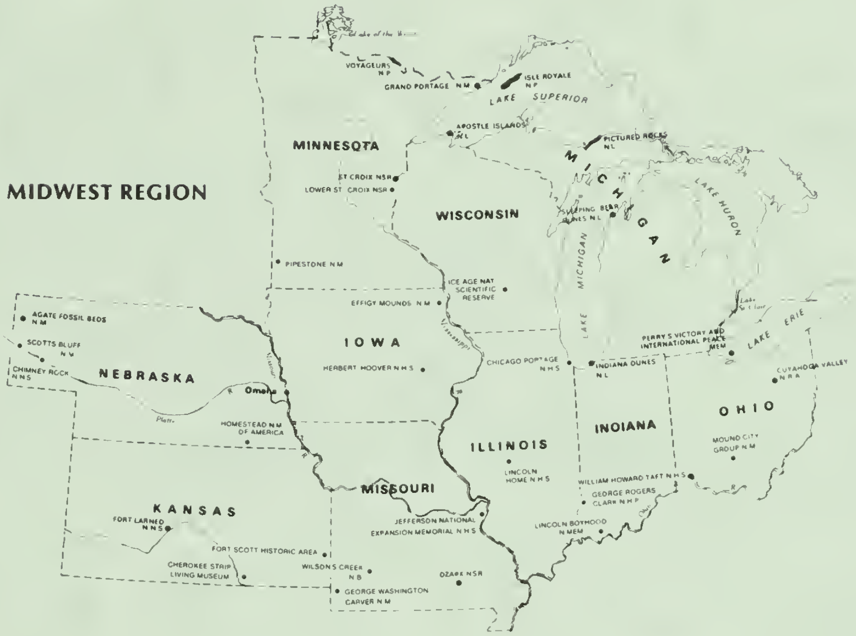

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